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13. ABSTRACT (Maximum 200 words)

THIS IS A PROGRESS REPORT ON AEROJET'S STUDIES OF EXPERIMENTS CURRENTLY UNDERWAY (E.G, PLANT GROWTH & DIMP & DCPD LYSIMETER TESTS). LYSIMETER APPARATI WERE LOADED WITH RECONSTRUCTED SOIL PROFILES FROM VARIOUS SAMPLING LOCATIONS. THESE LOCATIONS YIELDED SEVERAL DIFFERENT SOIL TYPES. SAMPLES OF DIMP (ME-14C) AND DCPD (X-14C) OF 3.05 MILLICURIES PER MILLIMOLE AND 3.04 MILLICURIES PER MILLIMOLE WERE OBTAINED FROM NEW ENGLAND NUCLEAR CORPORATION AND USED IN SOIL SAMPLES. YIELD DATA FROM THE 1, 8 AND 20 PPM DIMP GROWTH TESTS HAS BEEN EXAMINED.

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AEROJET ORDNANCE AND MANUFACTURING COMPANY
9236 East Hall Road
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DETERMINATION OF DECONTAMINATION CRITERIA

DIMP AND DCPD (U)

Report No. 1953-01(18)MP

Contract DAMD-17-75-C-5069

to

U. S. ARMY, Ft. Detrick
Fredrick, Maryland, 21701

Prepared by: P. A. O'Donovan Date: 7 February 1977

P. A. O'Donovan

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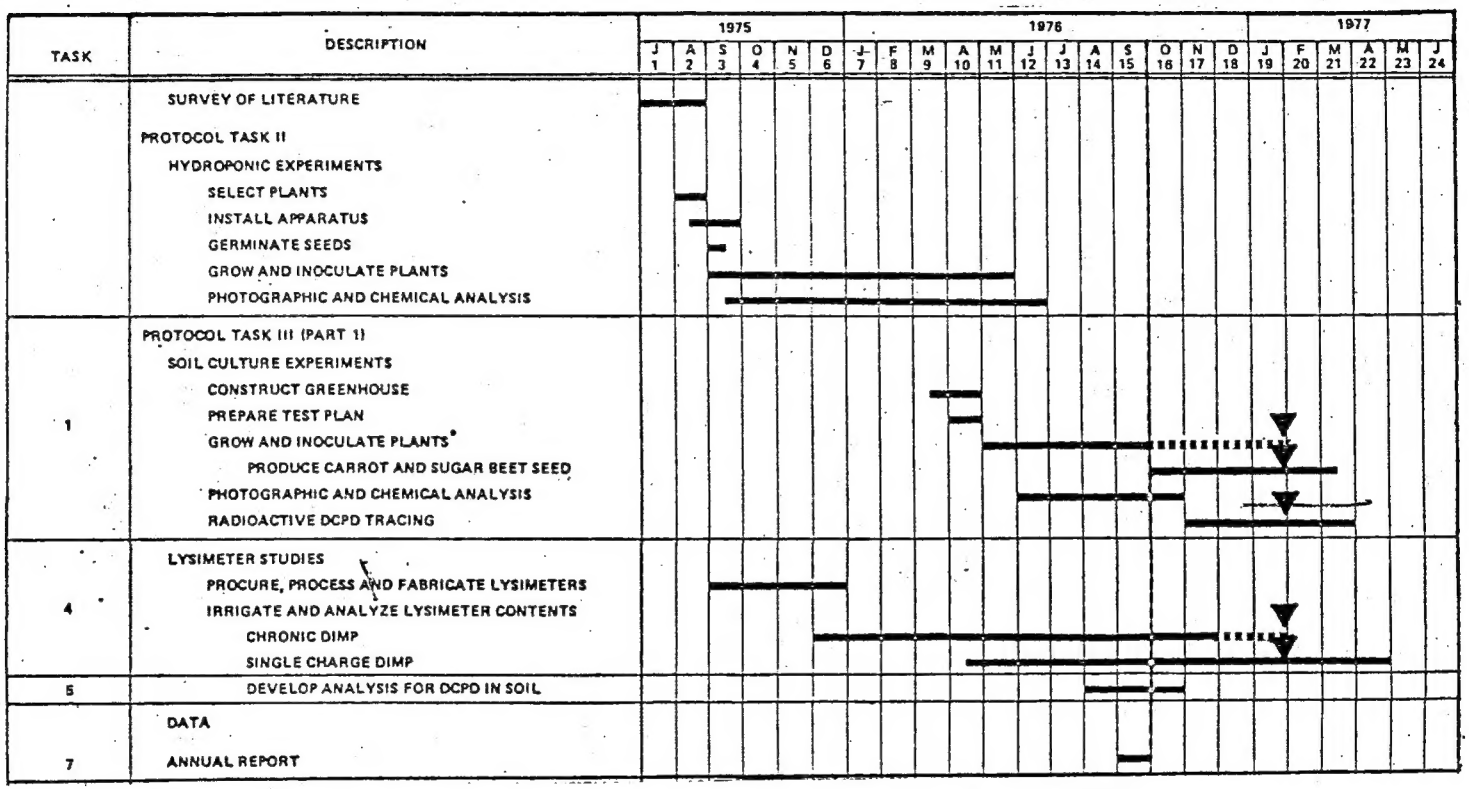

*POSSIBLE SLIPPAGE POINT. ADJUSTMENT OF CONTAMINANT AT THIS POINT SHIFTS ALL FOLLOWING PLANT WORK TO THE RIGHT.

▼ - Satisfactory Progress - on schedule

Determination of Decontamination Criteria - DIMP and DCPD

Research Task Schedule

Progress on items proposed for action during January 1977, is discussed in this report.

FULL SCALE LYSIMETER TESTS

Lysimeter apparati were loaded with reconstructed soil profiles from various sampling locations. These locations yielded several different soil types including:

Chino -	sandy clay loam
Brawley -	silty clay
Ventura -	clay loam
Fullerton -	sandy loam
Walnut -	clay loam

These soils were packed into five foot deep, epoxy coated, steel cylinders which were fitted with a series of porous ceramic tensiometer samples embedded at various soil depths. As the irrigation water percolates through the soil it is sampled by the various tensiometers. This irrigation water, in the amount of 12,887 ml. (2 inches of water depth) has been applied to the surface of the lysimeters on a biweekly basis in two modes. In one series (Group 1) the irrigation water contains 20 ppm of DIMP (diisopropylmethyl phosphonate) which is added to the soil column. In the other series (Group 2) plain distilled water is added to a soil column, the top one foot of which had previously been blended with DIMP to a concentration of 20 ppm.

During the most recent sampling period (January 1977) the ambient temperature and humidity have been such that the irrigation water did not evaporate as rapidly as in the past and the drainage period was extended from two weeks to four weeks. Figure 1 represents the "drainage ratio" of the Group 1

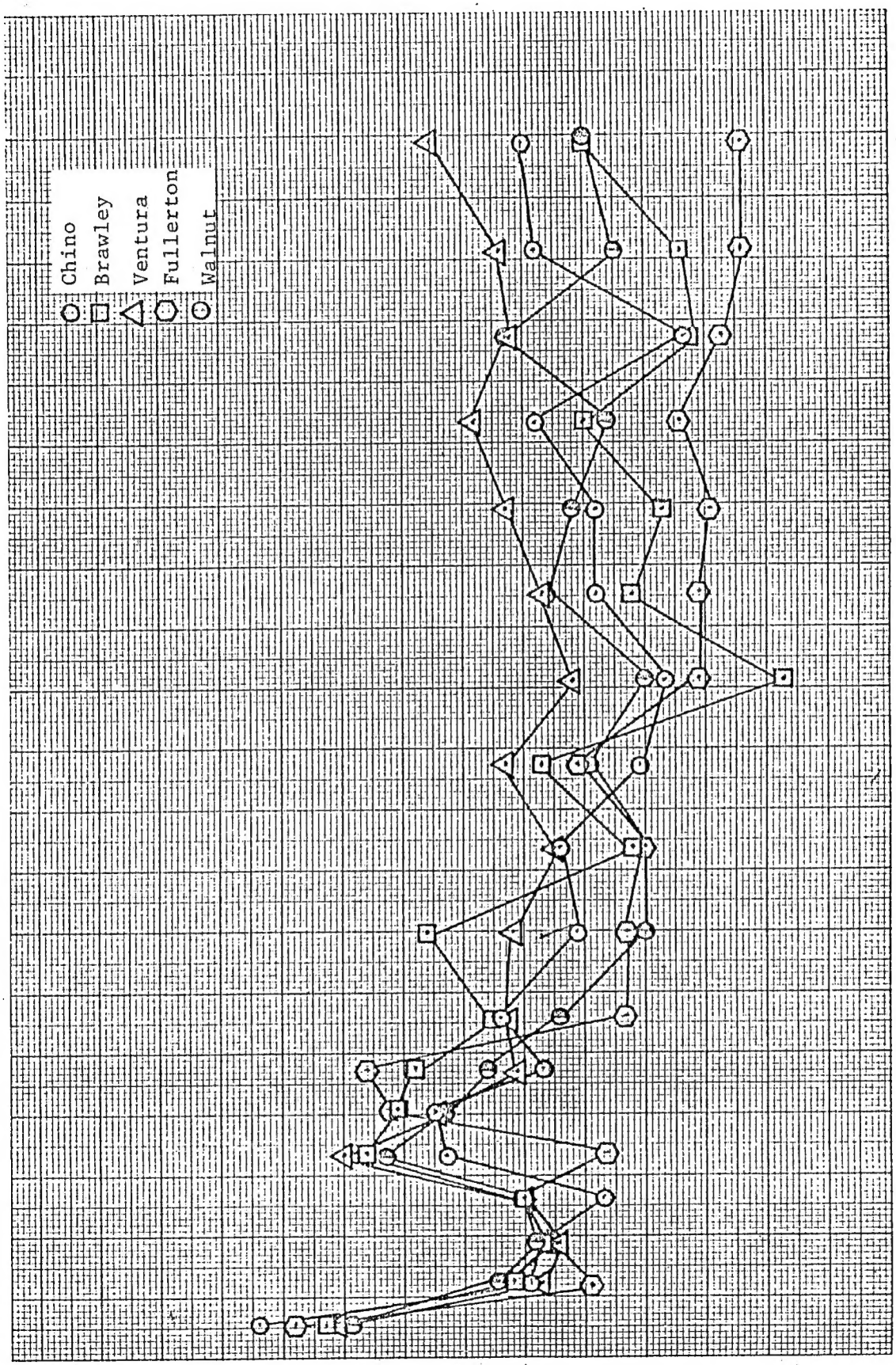

Figure 1. Drainage Ratios of Various Soils in Full Scale Lysimeter

Group 1

lysimeters (the volume of irrigation water collected divided by the volume of water applied). All of the points except the most recent one are averages of two successive measurements. The most recent one is a single measurement of the four week drainage. Figure 2 represents the drainage ratio from the Group 2 lysimeters. Figure 3 is a summation of the average drainage ratios of all the members within the groups.

The irrigation water sampled by the tensiometers has been subjected to gas-liquid chromatographic analysis for DIMP content. The data for the most recent Group I samples is shown in Table 1. Due to the prolonged drainage time the Group 2 data was not available as of this writing.

The soil in each of the lysimeters was sampled, by means of a soil coring tool, in six inch increments of depth plus a small surface sample. All the samples in a given lysimeter were taken at the same horizontal location. The most recent DIMP analyses of the soil samples are shown in Tables 2 and 3. These numbers appear to be compatible with previous similar assays. The chronic addition group has a thin layer of high concentration of DIMP which diminishes generally with depth. The single charge of DIMP is moving downward in a broad band and is currently being eluted from the bottom of the soil column.

As for the past several months the DIMP content of the water eluted from the Group 1 columns appears to be in general agreement with previous assays, all of the values being between 14 and 19 ppm.

RADIOACTIVE TRACING OF SOIL CONTAMINATION

Samples of DIMP [ME-14_C] and DCPD [X-14_C] (dicyclopentadiene) of 3.05 millicuries per millimole and 3.04 millicuries per millimole were obtained from

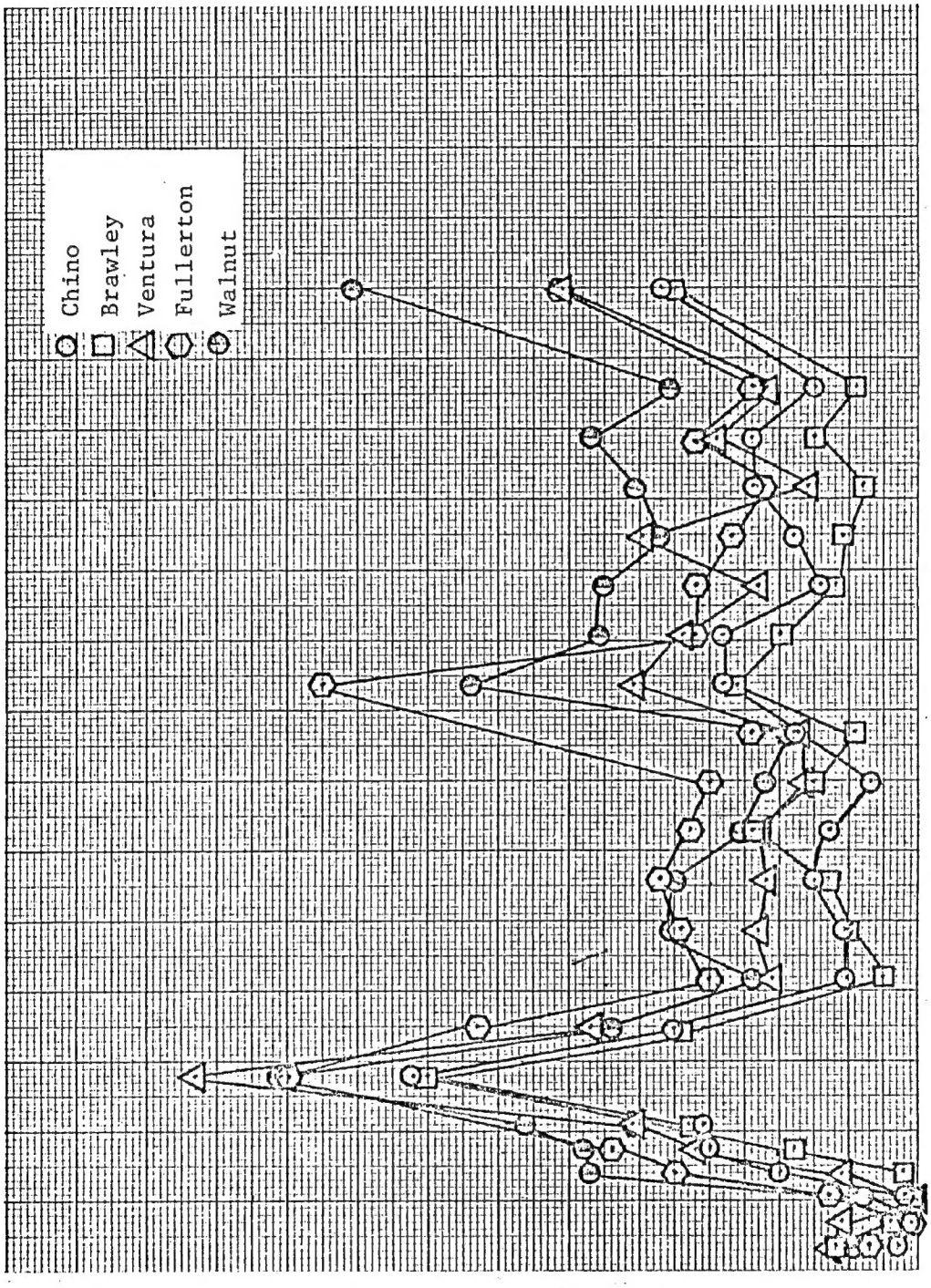

Figure 2. Drainage Ratios of Various Soils in Full Scale Lysimeters

Group 2

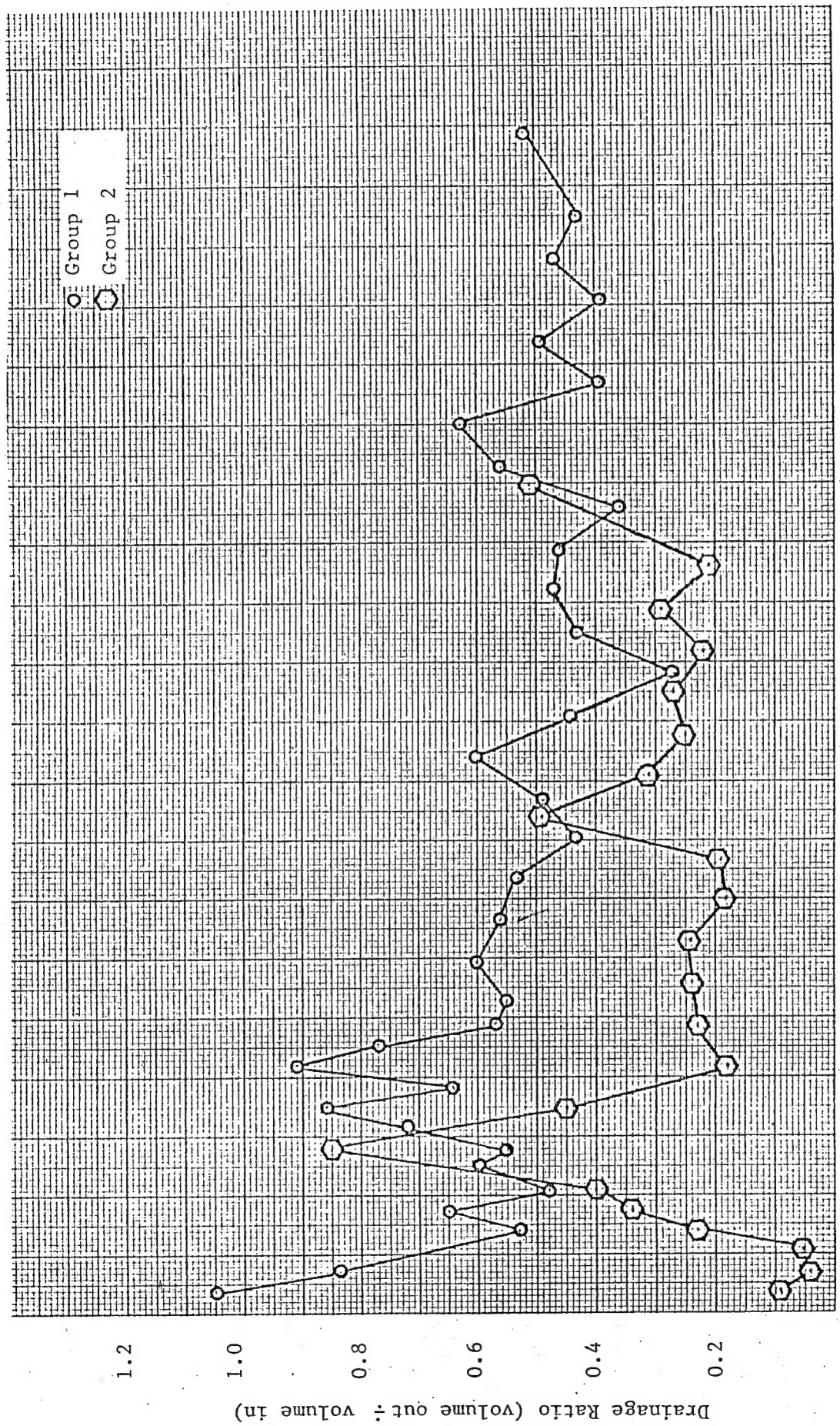

Figure 3. Drainage Ratios of Various Soils in Full Scale Lysimeters
Average of All Samples Within the Groups

Table 1

DIMP Content of Tensiometer Water Samples (Group 1 - East)

Depth	Ventura	Chino	Fullerton	Walnut	Brawley
		ppm @ 405 days			
6"	*	17.1	28.3	26.9	27.7
18"	6.7	16.5	18.0	7.5	26.0
30"	4.9	23.2	26.4	20.1	16.7
42"	8.6	17.5	25.3	14.5	17.1
54"	18.1	17.7	18.7	12.3	13.7
60"	14.3	18.4	15.6	18.7	15.5

* No sample

Table 2

DIMP Content of Soils Samples (ppm) (400 days)

Group 1

Depth	Ventura	Chino	Fullerton	Walnut	Brawley
0 (surface)	49.8	18.5	27.6	85.4	34.9
0 - 6"	5.9	5.7	8.0	13.5	10.0
6 - 12"	5.5	4.6	12.8	6.3	6.5
12 - 18"	2.9	3.7	6.9	2.6	6.5
18 - 24"	6.1	3.0	5.7	1.9	8.6
24 - 30"	3.4	3.2	7.7	2.7	8.0
30 - 36"	3.4	3.5	3.3	2.8	8.7
36 - 42"	3.2	3.8	2.5	1.2	7.7
42 - 48"	3.6	2.7	3.7	1.0	6.7
48 - 54"	3.7	3.8	4.4	2.9	7.0
54 - 60"	2.8	6.6	4.3	3.3	9.1

Table 3

DIMP Content of Soils Samples (ppm) (252 days)

Group 2

Depth	Ventura	Chino	Fullerton	Walnut	Brawley
0 (surface) *	*	*	*	*	*
0 - 6"	*	*	*	*	*
6 - 12"	*	*	*	*	*
12 - 18"	*	*	*	*	*
18 - 24"	*	*	*	*	*
24 - 30"	*	4.9	2.8	*	18.7
30 - 36"	13.4	14.0	11.0	*	23.9
36 - 42"	29.4	8.5	7.4	1.8	7.0
42 - 48"	14.3	7.5	4.9	5.6	2.0
48 - 54"	19.6	4.2	3.7	15.7	**
54 - 60"	**	**	4.6	12.5	**

* No sample

** <0.1 ppm

New England Nuclear Corporation. These materials were diluted and added to 4 inch deep soil samples contained in Pyrex test tubes and these inserted in a gas train as shown in Figure 4 . DIMP and DCPD were loaded in the soil homogeneously at 20 ppm. The first experiment has dry air flowing over the surface of the soil at approximately 100 milliliters per minute followed by bubbling into two solvent traps held in a dry ice bath. Samples of 1 inch increments of depth of soil plus the solvent traps have been submitted to New England Nuclear for extraction and liquid scintillation counting to determine the concentration of the chemicals still in the system. Upon receipt of the data from these preliminary tests planning of further elaborations such as moist soil and CO_2 traps downstream will be made. The 8 hour and 50 hour exposure samples for DCPD and the 14 hour samples for DIMP have been submitted. Additional samples are being exposed for longer periods subject to receipt of the analytical data.

SOIL CULTURE EXPERIMENTS

Yield data from the 1, 8 and 20 ppm DIMP growth tests has been examined. A limited amount of statistical manipulation has been done on this data as typified by Tables 4 and 5 and Figures 5 and 6 .

Table 4 presents the yield of edible portion of various plants, as a function of the concentration of contaminants. The average of the yield of the three positive control plants was used as the zero concentration yield. Also in Table 4 is the average yield at each concentration as a percentage of the maximum average.

With five plant types and two contaminants there are ten situations to evaluate. In four of these situations the maximum average yield occurred with zero contaminant. In the other six cases the maximum yield was obtained at some higher concentration. Figures 5 and 6 illustrate the situation.

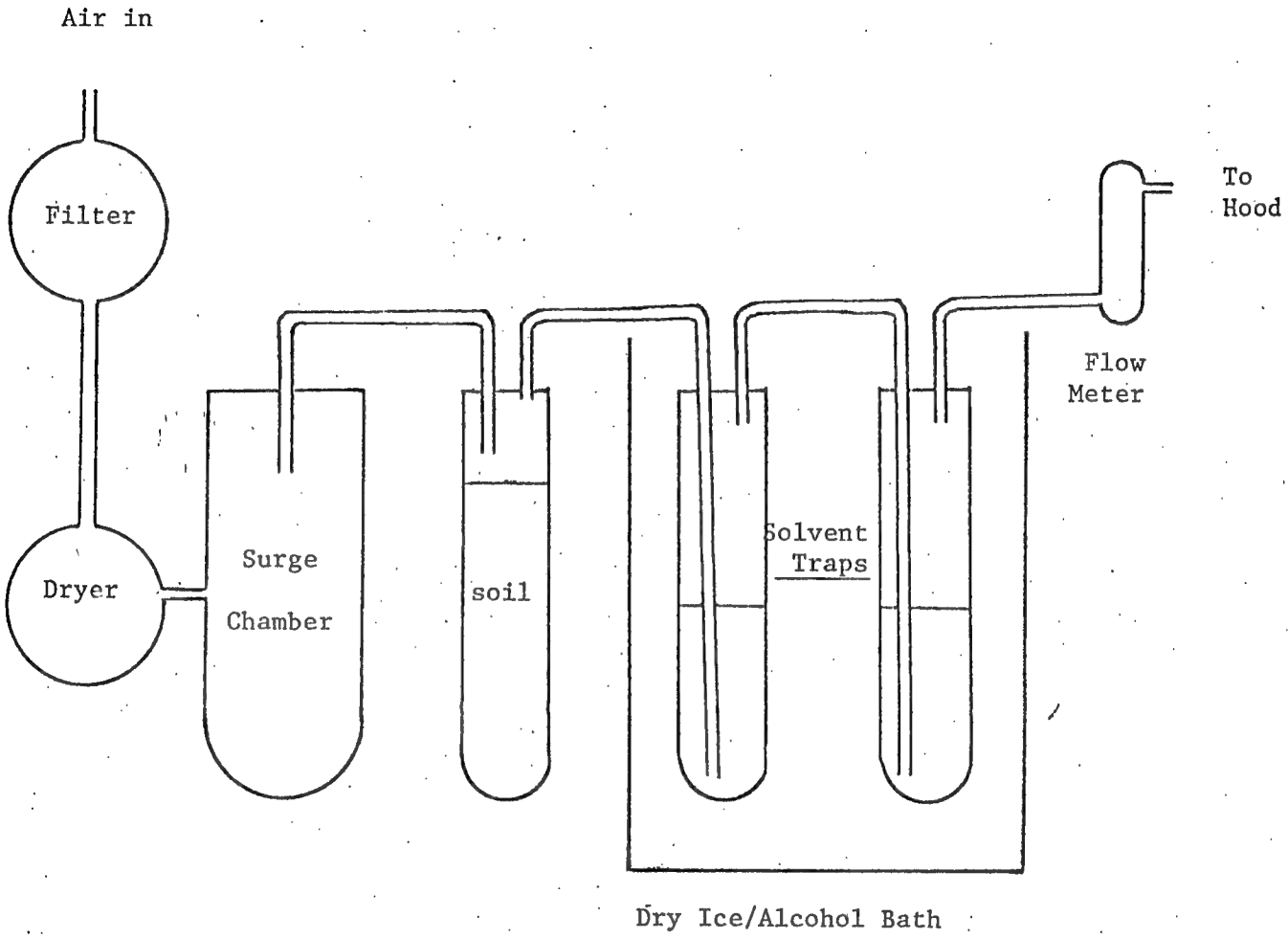

Figure 4. Laboratory Arrangement for Determining Evaporative Loss of Chemicals From Soil.

Table 4

YIELD OF FRUIT

Plant Type	Contaminant	PPM	Average Weight	% of Max. Average
Carrot	DIMP	0	119.21	100.00
		1	57.9	48.57
		8	58.6	49.16
		20	83.4	69.96
	DCPD	0	246.73	100.00
		1	101.0	40.94
		8	102.9	41.71
		20	137.8	55.85
Beet	DIMP	0	45.45	100.00
		1	39.8	87.57
		8	39.6	87.13
		20	30.5	67.11
	DCPD	0	74.3	100.00
		1	44.7	60.16
		8	44.5	59.89
		20	50.7	68.24
Alfalfa	DIMP	0	3.90	54.93
		1	4.19	59.01
		8	7.10	100.00
		20	2.32	32.58
	DCPD	0	3.70	96.61
		1	3.16	82.51
		8	3.83	100.00
		20	2.97	77.55

Table 4 : Yield of Fruit (cont'd)

Plant Type	Contaminant	PPM	Average Weight	% of Max. Average
Wheat	DIMP	0	2.22	77.08
		1	2.73	94.79
		8	2.88	100.00
		20	1.53	53.13
	DCPD	0	1.76	64.00
		1	1.15	41.82
		8	2.75	100.00
		20	1.39	50.55
Bean	DIMP	0	12.09	100.00
		1	12.06	99.75
		8	9.62	79.57
		20	6.85	56.66
	DCPD	0	10.34	78.39
		1	8.24	62.47
		8	10.28	77.94
		20	13.19	100.00

Tabulation of Average Weight of
Plant Parts @ 87 Days of Age

Plant Type	Average Weight (g) of					Number of Plants in Average	Contaminant Type	Conc. of Contaminant in H_2O (ppm)
	Leaf	Stem	Root	Edible Fruit	Total Plant			
Bean	2.59	5.84	0.40	5.33	14.64	8	Neg.Control	0
	7.24	9.97	0.58	8.24	20.14	6	DCPD	1
	3.75	6.08	0.35	10.28	21.59	10	"	8
	10.85	16.90	0.83	13.19	43.87	5	"	20
	6.13	7.99	0.51	14.00	29.88	2	Pos.Control	1
	17.49	16.73	0.69	12.39	49.50	1	"	8
	14.44	19.77	1.08	0.96	36.83	1	"	20
	3.34	11.11	0.64	12.06	27.56	7	DIMP	1
	3.83	12.65	0.58	9.62	26.94	5	"	8
	12.85	20.13	0.98	6.85	41.99	5	"	20
	7.74	27.66	1.67	16.68	54.28	1	Pos.Control	1
	10.89	20.06	1.18	9.24	42.19	1	"	8
	5.81	12.15	0.71	11.21	30.19	2	"	20

Table 5a. Yield of various plants exposed to DIMP or DCPD during their growth period

Tabulation of Average Weight of
Plant Parts @ 87 Days of Age

Plant Type	Average Weight (g) of					Number of Plants in Average	Contaminant Type	Conc. of Contaminant in H_2O (ppm)
	Leaf	Stem	Root	Edible Fruit	Total Plant			
Wheat	0.68	1.00	0.49	1.27	4.37	18	Neg.Control	0
	0.68	1.40	0.48	1.15	5.45	24	DCPD	1
	1.41	2.07	1.67	2.75	10.73	12	"	8
	1.01	1.52	0.83	1.39	6.72	16	"	20
	0.67	0.67	0.52	1.40	5.25	3	Pos.Control	1
	1.10	1.29	0.91	2.65	7.50	3	"	8
	0.84	1.43	0.65	1.37	5.71	4	"	20
	0.88	1.68	0.75	2.73	7.98	16	DIMP	1
	1.10	2.05	0.68	2.88	8.98	16	"	8
	0.62	1.30	0.30	1.53	5.32	15	"	20
	1.01	1.67	0.98	2.75	7.75	3	Pos.Control	1
	1.24	2.06	0.59	2.52	7.89	2	"	8
	0.83	1.41	0.34	1.49	5.82	3	"	20

Table 5b. Yield of various plants exposed to DIMP or DCPD during their growth period.

Tabulation of Average Weight of
Plant Parts @ 116 Days of Age

Plant Type	Average Weight (g) of					Number of Plants in Average	Contaminant Type	Conc. of Contaminant in H_{20} (ppm)
	Leaf	Stem	Root	Edible Fruit	Total Plant			
Alfalfa	1.10	1.55	1.22		4.18	81	Neg.Control	0
	1.94	2.15	1.47		6.20	65	DIMP	1
	3.14	3.96	2.36		10.31	41	"	1
	1.13	1.19	0.94		3.73	84	"	8
	2.62	2.82	1.59		7.37	13	Pos.Control	1
	1.56	1.88	1.15		5.06	16	"	8
	1.33	1.79	1.16		4.28	16	"	20
	1.42	1.74	2.25		5.67	57	DCPD	1
	1.88	1.95	1.88		6.25	53	"	8
	1.51	1.46	1.97		5.31	55	"	20
	1.05	1.03	1.01		3.22	22	Pos.Control	1
	4.68	2.14	5.06		13.94	5	"	8
	3.13	3.08	1.07		10.24	8	"	20

Table 5c. Yield of various plants exposed to DIMP or DCPD during their growth period.

Tabulation of Average Weight of
Plant Parts @ 211 Days of Age

Plant Type	Average Weight (g) of					Number of Plants in Average	Contaminant Type	Conc. of Contaminant in H_2O (ppm)
	Leaf	Stem	Root	Edible Fruit	Total Plant			
Sugar Beet	23.9	N/A	40.9	See Root	64.8	27	Neg.Control	0
	13.8	"	39.8	"	53.6	16	DIMP	1
	7.3	"	39.6	"	46.9	18	"	8
	7.9	"	30.5	"	38.4	17	"	20
	9.8	"	30.7	"		5	Pos.Control	1
	18.3	"	55.5	"		5	"	8
	7.7	"	53.3	"		3	"	20
	21.5	N/A	44.7	See Root	66.2	22	DCPD	1
	14.1	"	44.5	"	58.6	16	"	8
	21.1	"	50.7	"	71.8	16	"	20
	15.1	"	66.5	"	81.6	4	Pos.Control	1
	26.1	"	84.4	"	110.5	2	"	8
	49.1	"	79.8	"	128.9	2	"	20

Table 5d. Yield of various plants exposed to DIMP or DCPD during their growth period.

Tabulation of Average Weight of
Plant Parts @ 229 Days of Age

Plant Type	Average Weight (g) of					Number of Plants in Average	Contaminant Type	Conc. of Contaminant in H_2O (ppm)
	Leaf	Stem	Root	Edible Fruit	Total Plant			
Carrot	13.7	19.6	126.6	See Root		21	Neg.Control	0
	5.2	8.1	57.9	"	71.2	33	DIMP	1
	5.6	10.2	58.6	"	74.4	46	"	8
	9.2	13.6	83.4	"	106.2	16	"	20
	4.5	4.6	42.3	"	51.4	12	Pos.Control	1
	26.7	35.6	318.3	"	380.6	2	"	8
	34.8	33.1	381.6	"	449.5	2	"	20
	12.2	8.9	101.0	See Root	122.1	26	DCPD	1
	13.6	19.1	102.9	"	135.6	16	"	8
	18.7	28.6	137.8	"	185.1	9	"	20
	48.0	43.8	647.4	"	739.2	1	Pos.Control	1
	23.8	25.5	49.6	"	98.9	4	"	8
	76.9	60.8	634.6	"	772.3	1	"	20

Table 5e. Yield of various plants exposed to DIMP or DCPD during their growth period.

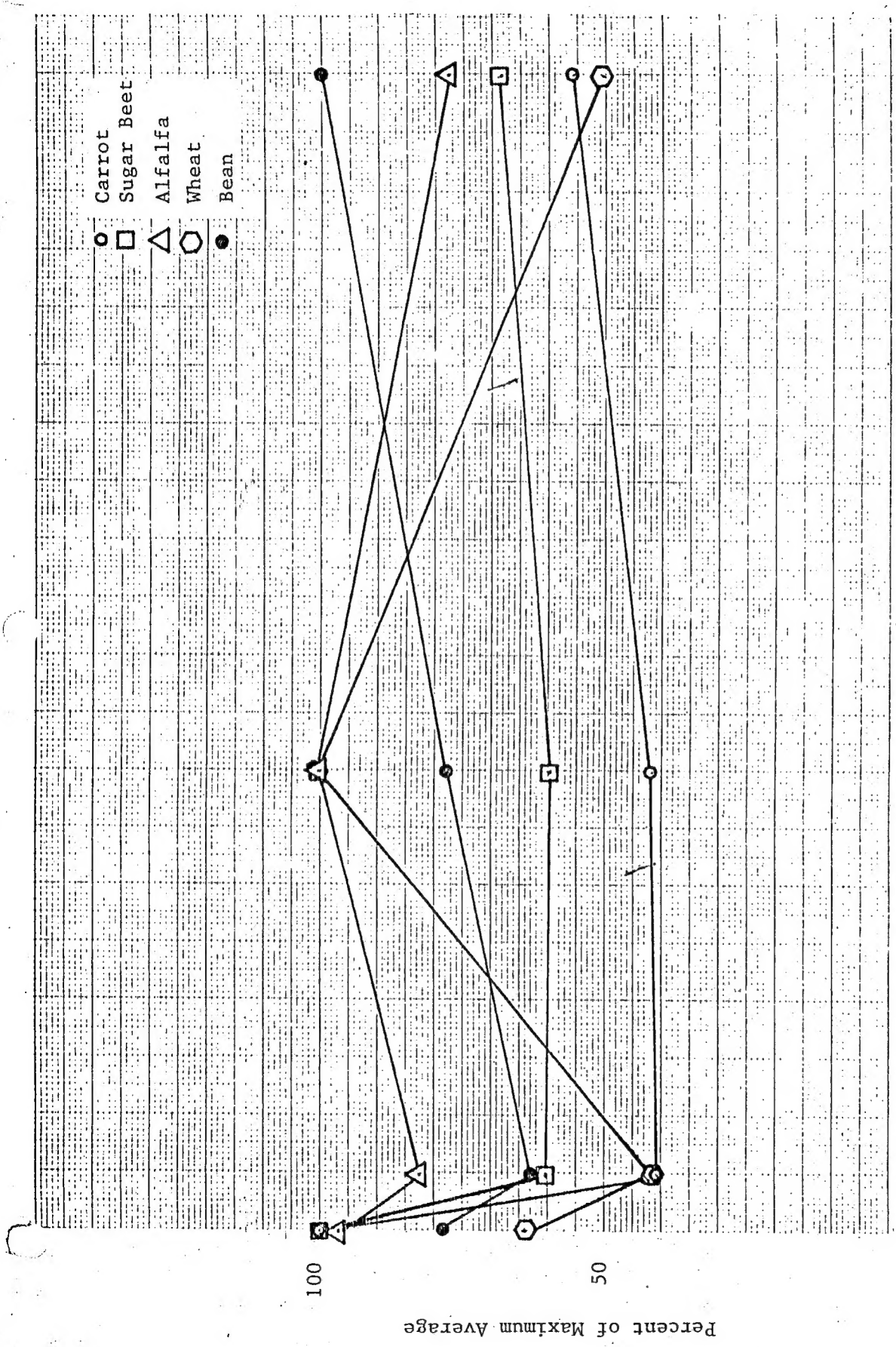

Figure 5. Effect of dose level of DCPD on yield of various plants

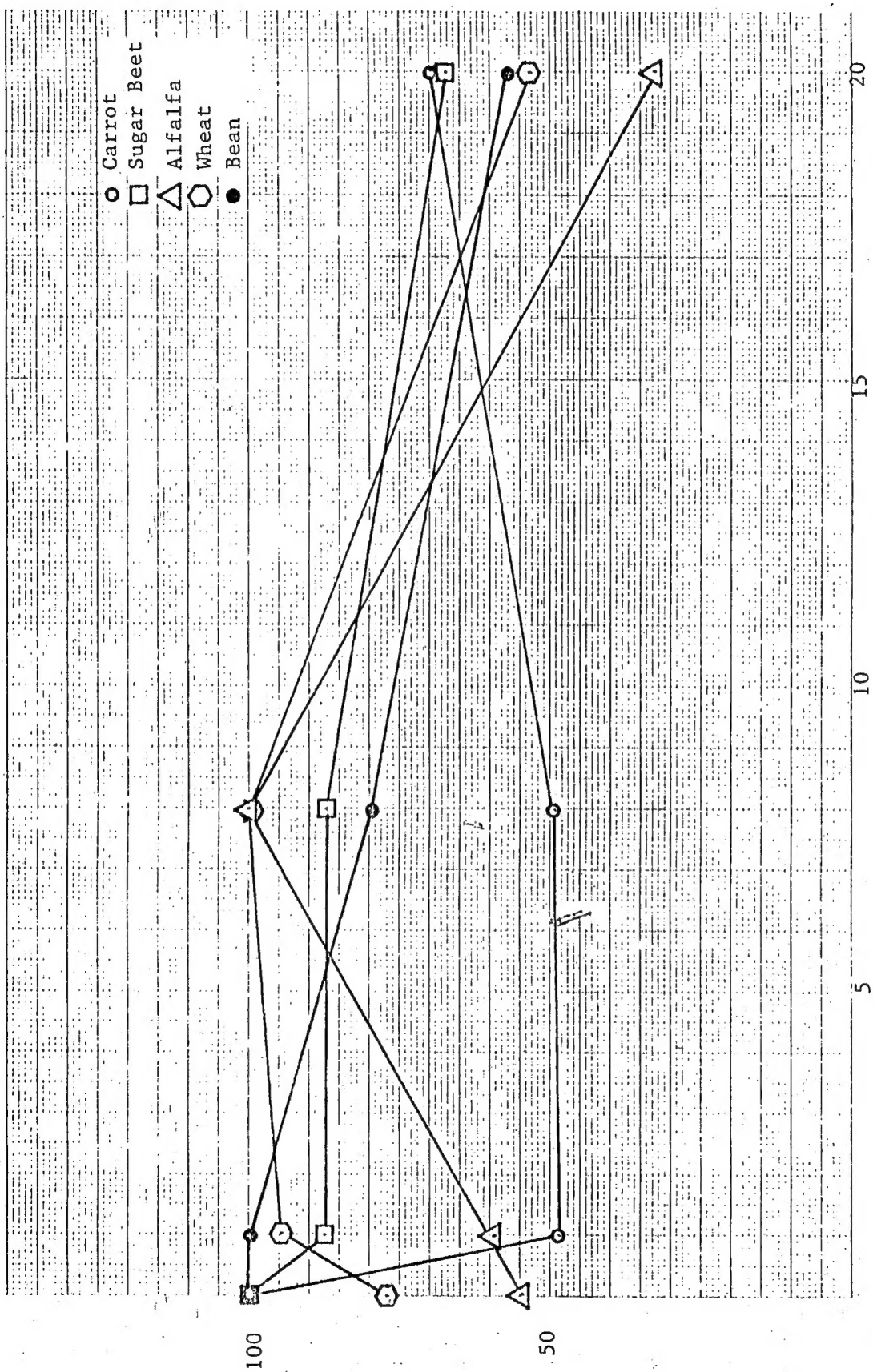

Figure 6. Effect of dose level of DIMP on yield of various plants

We may conclude that in some cases the nominal contaminants are actually growth promoters. The only evidence available from the strictly statistical point of view is the yields of the positive control plants. These vary so widely one from another, in the case of the carrots, that it can only be concluded that plant-to-plant variation is so great as to completely mask the results of the treatment. In other words, the signal-to-noise ratio is very low.

It is the opinion of the statistician at this point that a much more extensive series of experiments, from the point of numbers of plants and contaminant concentration levels is required to enable mathematical statements of the effects of DIMP and DCPD on plant growth.

Proposed Activity for February 1977

- o Harvest plants from the range finding soil growth experiments to determine effective dose levels of contaminants.
- o Continue radioactive DIMP and DCPD in soil evaporation/decomposition experiments.
- o Run ancillary analyses on soil and tissues from growth tests terminated in December.
- o Continue treatment and analysis of lysimeter soil and water samples.
- o Begin terminal sampling and analyses of chronic DIMP lysimeters.